Adapting Coal for the 21st Century

Jonathan E. Schrag
Hudson Strategic Energy Advisors

West Virginia Energy Summit
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**Mission:** Advise clients on low-carbon energy technology, finance, and policy

**Practice:**
- Carbon market architecture: Int’l, US, RGGI, WCI
- Advanced fossil fuel technologies and projects
- Carbon capture and storage policy
- Carbon Investment strategy
Why Coal?
## Table 9  Aggregation of global fossil energy sources all occurrences, in Gtoea

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>103</td>
<td>3.21</td>
<td>150</td>
<td>145</td>
<td>295</td>
<td></td>
</tr>
<tr>
<td>Unconventional</td>
<td>6</td>
<td>0.16</td>
<td>183</td>
<td>336</td>
<td>519</td>
<td>1,824</td>
</tr>
<tr>
<td><strong>Natural gas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>48</td>
<td>1.87</td>
<td>141</td>
<td>279</td>
<td>420</td>
<td></td>
</tr>
<tr>
<td>Unconventional</td>
<td>—</td>
<td>—</td>
<td>192</td>
<td>258</td>
<td>450</td>
<td>387</td>
</tr>
<tr>
<td>Clathrates</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>18,759</td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td>134</td>
<td>2.16</td>
<td>1,003</td>
<td>2,397</td>
<td>3,400</td>
<td>2,846</td>
</tr>
<tr>
<td><strong>Total fossil</strong></td>
<td>291</td>
<td>7.40</td>
<td>1,669</td>
<td>3,415</td>
<td>5,084</td>
<td>23,815</td>
</tr>
</tbody>
</table>

aSources: Historical consumption (46). Reserves, resources, and occurrences, see Tables 2–8.

— = negligible volumes.

bReserves to be discovered or resources developed to resources.

cResource base is the sum of reserves and resources.

H. Rogner, 1997

dIncludes natural gas liquids.
Economic development requires energy.

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Coal can power industrializing Asia, Europe, and North America

Proved reserves at end 2006
 Thousand million tonnes (share of anthracite and bituminous coal is shown in brackets)

- Middle East: 0.4 (0.4)
- S. & Cent. America: 19.9 (7.7)
- Africa: 50.3 (50.2)
- North America: 264.4 (115.7)
- Europe & Eurasia: 287.1 (112.3)
- Asia Pacific: 296.9 (192.6)
Fossil fuels are fungible

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The Climate challenge to coal

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U.S. Milestones Toward Carbon Constraints

- U.S. Supreme Court certifies CO2 as a “pollutant” under Clean Air Act.
- RGGI states adopt rules to auction permits for 2008
- CA imposes 1,100 lbs/KWh performance standard
- Lieberman-Warner outlines proposed US climate policy
- NARUC issues suggested guidelines for US CO2 cap and trade
- Federal Ninth Circuit rejects U.S. emissions rules for light trucks as “insufficiently measuring the expected costs of carbon dioxide emissions”
- Multiple coal power plants cancelled
550ppm of CO2 Imposes a Carbon Allowance

Past 2015

Projected Exhaustion of Carbon Allowance

2025

2035

2045

2055

2065

2075

Our Carbon Allowance: 900 Gt C total ≈ 550 ppm

Carbon capture and storage increases our carbon allowance by 5 times

Total Fossil Carbon Resources:
5000 Gt C total

Excludes methane hydrates

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The Stabilization Triangle

Billions of Tons Carbon Emitted per Year

16
8
4
0

1950 2000 2050 2100

Historical emissions

Current path = “ramp”

Stabilization Triangle

Flat path →

Easier CO₂ target
~850 ppm

Interim Goal

Tougher CO₂ target
~500 ppm

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Stabilization Wedges

Billions of Tons Carbon Emitted per Year

16 GtC/y

Eight "wedges"

Goal: In 50 years, same global emissions as today

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A “wedge” is a strategy to reduce carbon emissions that grows over 50 years from zero to 1.0 GtC/yr.

50 years → Total = 25 Gigatons carbon

- Triple the world’s nuclear electricity capacity by 2055
- Double current natural gas supply by 2055
- Implement CCS at 800 GW coal electric or 1600 GW natural gas electric plants
- Replace all the world’s incandescent bulbs with CFL’s (1/4 of one wedge)
- Increase current wind capacity by 30 times
- Increase current solar capacity by 700 times
- With current practices, plant all India with biofuels

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“Carbon capture and storage is the critical enabling technology for continued coal use.”

- MIT “The Future of Coal”
MAGNITUDE OF CARBON CAPTURE AND STORAGE

Implement CCS at
• 800 GW coal electric plants or
• 1600 GW natural gas electric plants

U.S. SPENDS $500 BILLION ON RETAIL ELECTRICITY

There are currently three storage projects that each inject 1 million tons of CO₂ per year — by 2055 need 3500.

Graphic courtesy of Alberta Geological Survey

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U.S. Injection activity Versus CO2 emissions

Sources: Wilson, Johnson, and Keith, 2003
Coal’s New Platform

- Long-term commitment to deployment of CCS with significant research spending and persuasive pathway
- CCS regulatory framework by 2009: jurisdiction, property rights, liability, (IOGCC)
- Regional carbon storage infrastructure partnerships to promote project deployment: geologic storage, post-combustion, pre-combustion
- Near-term commitment to high-efficiency plants
- Engagement with carbon policy: Support for cap and trade

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Energy Security and Environment: The Connection

Politics Imposes Need for Low-carbon Technologies
- Efficiency
- Biofuels
- Gasification
- Carbon Capture and Storage

Opportunities for Advanced Coal Applications
- Coal to Liquids
- Biomass Co-Firing
- Zero-Emission Coal Power Plants

Lower Emissions and Reduced Oil Consumption

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Global Emissions Arithmetic 101

Fossil Fuel Burning

12 billion tons go in

800 billion tons carbon

3 + 3 = 6 billion tons go out

6 billion tons added to atmosphere annually

Ocean

Land Biosphere (net)

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Potential Global Emissions Growth

![Graph showing potential global emissions growth scenarios]

- **Closing the Gap**
- **Plus Population Growth**
- **1% energy intensity reduction**
- **Constant growth**
- **1.5% energy intensity reduction**
- **2.0% energy intensity reduction**

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## Gasoline and CTL Under Carbon Constraints

<table>
<thead>
<tr>
<th>Gasoline (b/d)</th>
<th>CO2 Cost/Ton</th>
<th>CO2 Emissions</th>
<th>Total CO2 Cost</th>
<th>CO2 Cost/Bbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>100,000</td>
<td>$12</td>
<td>27,000</td>
<td>$324,000</td>
<td>$3.24</td>
</tr>
<tr>
<td>100,000</td>
<td>$24</td>
<td>27,000</td>
<td>$648,000</td>
<td>$6.48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CTL (b/d)</th>
<th>CO2 Cost/Ton</th>
<th>CO2 Emissions</th>
<th>Total CO2 Cost</th>
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<td>600,000</td>
<td>$6</td>
</tr>
<tr>
<td>100,000</td>
<td>$24</td>
<td>50,000</td>
<td>1,200,000</td>
<td>$12</td>
</tr>
</tbody>
</table>

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## Proposed Bills with Cap and Trade Systems for GHG

<table>
<thead>
<tr>
<th>Title and Sponsors</th>
<th>Reduction Target and Timeframe</th>
<th>Significant Aspects</th>
</tr>
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<tbody>
<tr>
<td><strong>Climate Stewardship and Innovation Act (S. 280)</strong> Lieberman (CT) and McCain (AZ)</td>
<td>Brings emissions to 2004 levels by 2012, to 1990 levels by 2020, to 22% below 1990 levels by 2030, and to 60% below 1990 levels by 2050.</td>
<td>Caps electric power, industrial, commercial, and transport sectors (economy wide). Includes provision for clean development mechanism by which US companies gain credit for emissions reductions they sponsor in developing countries. Provisions for expansion of nuclear power.</td>
</tr>
<tr>
<td><strong>Global Warming Pollution Reduction Act (S.309)</strong> Sanders (VT) and Leahy (VT)</td>
<td>Stabilize global greenhouse gas concentrations below 450ppm; US reductions to 1990 levels by 2020 and 80% below that by 2050.</td>
<td>Economy wide caps. National renewable energy quotas and energy efficiency goals with credit trading programs.</td>
</tr>
<tr>
<td><strong>Electric Utility Cap and Trade Act (S. 317)</strong> Feinstein (CA) and Carper (DE)</td>
<td>Caps current emissions through 2011, then at 2001 levels by 2012, thereafter cap lowers further 1% each year through 2020 subject to EPA review.</td>
<td>Power sector only. Specifies auctioning of credits (not allocation) and use of offsets. Establishes independent scientific panel to make recommendations to the EPA every 4 years on the reduction rate required.</td>
</tr>
<tr>
<td>Bill Title</td>
<td>Description</td>
<td>Notes</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
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<tr>
<td>Climate Stewardship Act (H.R. 620)</td>
<td>Emissions stabilize at current levels from 2012 to 2019, then are reduced 15% by 2020, 38% by 2030, 75% by 2050 (which equals 70% below 1990 levels).</td>
<td>Same as Lieberman/McCain except that offset credits may account for only 15% of emissions reductions and &quot;early action&quot; credits limited to 20% of cap. Does not contain Senate version's nuclear provisions.</td>
</tr>
<tr>
<td>Global Warming Reduction Act (S.485)</td>
<td>Reduce emissions to 60% 1990 levels by 2050, through increasing annual reductions starting at 1.5% a year for the first 10 years.</td>
<td>Economy wide caps. National renewable energy quota of 20% by 2020. National renewable transport fuels standard.</td>
</tr>
<tr>
<td>Safe Climate Act (H.R. 1590)</td>
<td>Emissions freeze at 2009 levels in 2010. Beginning in 2011, emissions cut 2% per year, falling to 1990 levels by 2020. Beginning in 2021, annual emissions cuts of 5% per year falling to 80% below 1990 levels by 2050.</td>
<td>National renewable energy quota of 20% by 2020. Energy efficiency targets increase from 0.25% of electricity sales in 2010 to 1% of sales in 2012 and each year thereafter through 2020.</td>
</tr>
<tr>
<td>Clean Air Planning Act (S. 1177)</td>
<td>Caps power plant emissions at today's levels in 2012, at 2001 levels in 2015. Thereafter, annual reductions to achieve 25% below 1990 levels by 2050.</td>
<td>Power sector only, offsets allowed, output based allocation system (not auctions), includes a new entrant reserve (carbon credits reserved for allocation to newly built installations).</td>
</tr>
<tr>
<td>Clean Air /Climate Change Act of 2007 (S. 1168)</td>
<td>Power plants emissions capped at 2.3 billion tons (2006 levels) in 2011, at 2.1 billion in 2015, 1.8 billion in 2020 (1990 levels), and 1.5 billion in 2025 and beyond (17% below 1990 levels).</td>
<td>Power sector only, allows offsets, includes new entrant reserve of no more than 5% of the year's allowances, includes emissions performance standard for plants built after 2015 (no more than 1100 lbs co2/mwh).</td>
</tr>
<tr>
<td>Bill Name</td>
<td>Description</td>
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<td>---------------------------------------------------------------</td>
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</tr>
<tr>
<td>Clean Power Act (S. 1201) Sanders (VT)</td>
<td>Power sector only. CO2 performance standard for new plants, renewable energy quota of 20% by 2020. Energy efficiency targets with credit trading system to achieve gradual reduction of peak demand and overall electricity use. Same as S. 1168 for CO2 and specifies that if no greenhouse gas bill has been passed by 2012 then emissions from power plants must be decreased by 3% each year.</td>
<td></td>
</tr>
<tr>
<td>Low Carbon Economy Act Bingaman (NM) and Specter (PA)</td>
<td>Reduction of greenhouse gases to 2006 levels by 2020 and to 1990 levels by 2030. Limits cost of allowances to $12/ton CO2e in 2012, rising by 5% above inflation each year after that. Allowance allocation through 2017: 53% free, 24% auctioned, rest reserved for certain sectors and projects. Tariffs on goods from high emitting countries.</td>
<td></td>
</tr>
<tr>
<td>America's Climate and Energy Security Act (S. 2191) Lieberman (CT and Warner (VA).)</td>
<td>Cut US GHG emissions to 1990 levels by 2020, 65% below 1990 by 2050. &quot;Carbon market Efficiency Board&quot; overseas market of allowances to prevent volatility, tariffs on goods from high emitting countries, allowance allocation: 51% auctioned in 2012 increasing to 100% in 2036. 20% of auction proceeds reserved for low-income consumers.</td>
<td></td>
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</tbody>
</table>